

**EXPANDED SITE INSPECTION REPORT****NATIONAL PARK SERVICE  
CHARLESTON HARBOR SITE  
CHARLESTON, SOUTH CAROLINA****TABLE OF CONTENTS**

<u>Section</u>	<u>Subject</u>	<u>Page</u>
	Signature Page.....	iv
	Executive Summary.....	v
I.	Introduction .....	1
II.	Site Background and History .....	1
III.	Previous Assessment Activities .....	3
	A. Surrounding Sites .....	3
	B. National Park Service Charleston Harbor Site .....	4
	C. Ambient Air .....	5
IV.	Hydrogeologic and Geologic Setting .....	5
	A. Regional Setting .....	5
	B. Site Setting .....	7
	C. Area Groundwater Use .....	8
V.	Sampling And Analysis.....	9
	A. Surface and Subsurface Soil .....	9
	B. Groundwater .....	13
	C. Surface Water and Sediment .....	16
VI.	Exposure Pathways .....	18
VII.	Mitigation and Containment.....	20
VIII.	Conclusions.....	20

**Expanded Site Inspection Report, Charleston Harbor Site  
Table of Contents (continued)**

**Tables**

- 1 Chain of Title
- 2 Summary of Previous Assessment Activities
- 3 Analytes Detected in Surface Soil (0"-6")
- 4 Organic Compounds Detected in Soil at the Water Table (3'-4')
- 5 Metals Detected in Soil at the Water Table (3'-4')
- 6 Semi-Volatile Organic Compounds Detected in Soil at the Interface with the Uppermost Aquitard
- 7 Volatile Organic Compounds Detected in Soil at the Uppermost Aquitard and in Groundwater
- 8 Metals Detected in Soil at the Interface with the Uppermost Aquitard
- 9 Organic Compounds Detected in Soil 2' to 5' Into the Uppermost Aquitard
- 10 Metals Detected in Soil 2' to 5' Into the Uppermost Aquitard
- 11 Organic Compounds Detected in Groundwater and Free Product
- 12 Target Analyte List Parameters Detected in Groundwater and Free Product
- 13 Organic and Inorganic Parameters Detected in Sediments and Surface Water of the Cooper River Estuary

**Figures**

- 1 Site Location Map
- 2 Previous Soil Sample Locations
- 3 Site Map Showing Boring and Excavation Locations
- 4 Monitoring Well and Soil Sample Locations
- 5 Structural Contour Map of the Uppermost Aquitard
- 6 Groundwater Contour Map for the Uppermost Aquifer
- 7 Total Target Compound List Polynuclear Aromatic Compounds in Soil and Groundwater
- 8 Distribution of PCBs in Soil and Groundwater
- 9 Groundwater Isoconcentration Map - Total Target Compound List Polynuclear Aromatic Hydrocarbons
- 10 Distribution of Lead and Mercury in Soil and Groundwater

**Expanded Site Inspection Report, Charleston Harbor Site  
Table of Contents (continued)**

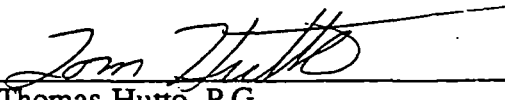
**Appendices**

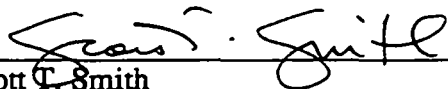
- I "Historical Study, Fort Sumter National Monument, Dockside II"
- II Post-1938 Historical Information
- III June 1992 "Site Screening Investigation" - Calhoun Park/Ansonborough Homes/Coal Gas"
- IV November 1989 Appendix IX Analysis of Two Soil Samples - Charleston Harbor Site
- V May 1991 "Preliminary Assessment Report" - Charleston Harbor Site
- VI October 1991 Analysis of Soil and Air Samples - Charleston Harbor Site
- VII Lithologic Logs - Preliminary Soil Investigation and Foundation Investigations ..
- VIII Monitoring Well Construction Details
- IX Sieve and Permeability Analysis
- X Certificates of Analysis
- XI Monitoring Well Development and Sampling Techniques
- XII Surface Water and Sediment Sampling Techniques

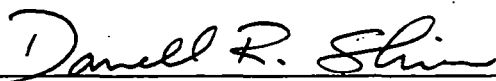
## Signature Page

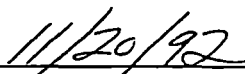
This document entitled "Expanded Site Inspection Report" has been prepared for the Charleston Harbor Site located on Concord Street in Charleston, South Carolina. It has been prepared by Thomas Hutto in accordance with accepted quality control practices at the request of and for the exclusive use of the National Park Service, the Environmental Protection Agency, the South Carolina Department of Health and Environmental Control, and the City of Charleston. It has been reviewed by the undersigned.

### GENERAL ENGINEERING LABORATORIES

  
\_\_\_\_\_  
Thomas Hutto, P.G.  
Senior Hydrogeologist

  
\_\_\_\_\_  
Scott T. Smith  
Project Scientist

  
\_\_\_\_\_  
Darrell R. Shier, P.E.  
Senior Engineer

  
\_\_\_\_\_  
Date

## EXPANDED SITE INSPECTION REPORT

### NATIONAL PARK SERVICE CHARLESTON HARBOR SITE CHARLESTON, SOUTH CAROLINA

#### EXECUTIVE SUMMARY

The 4-acre National Park Service (NPS) Charleston Harbor Site (CHS) is located adjacent to the Cooper River in an area that has been developed for commercial and industrial use since the mid-1700s. The NPS plans to construct a visitors center and tour boat dock on the site. The tour boats will provide transportation to the Fort Sumter National Historical Monument, which is located on an island in Charleston Harbor. A portion of the site will also be leased to the City of Charleston for construction of the South Carolina Aquarium.

The majority of the CHS was a tidal flat until progressively filled after 1940. Previous investigations of surrounding sites and limited investigations of the CHS identified soil and groundwater impact from polynuclear aromatic hydrocarbons (PAHs) associated with creosote and coal gasification processes. This Expanded Site Inspection (ESI) of the CHS was performed to: 1) identify the extent and severity of impact to site soils and groundwater, as well as to surface water and sediments of the adjacent Cooper River, 2) identify potential exposure pathways, and 3) provide the EPA with adequate data to rank the site using the Hazard Ranking System.

To accomplish this, 31 soil samples, 12 groundwater samples, four river sediment samples, and three surface water samples were analyzed. The analyses detected impact to soils and groundwater primarily from PAHs with lesser amounts of impact from metals and polychlorinated biphenyls (PCBs).

The impact is primarily limited to groundwater and subsurface soils on the northern two-thirds of the site; except for localized areas, the soils at land surface are not significantly impacted. No pure wastes (free product) were identified except in one monitoring well located on the northern site boundary. When removed from the well, however, the free product did not reenter the well in measurable volumes. This indicates that it is present in only small volumes in this area.

The location and distribution of contaminants suggest that the primary source of impact is discharges from a former manufactured gas plant (MGP) located immediately

(northwest of the site.) The most significant impact on the CHS site is located in proximity to this former plant. Other impact detected at the site may have been caused by:

- Heavy metal containing marine paints used on the site and surrounding sites.
- Lead impacted stormwater runoff which crosses the site in subsurface stormwater piping. Extremely elevated lead concentrations are common in soils along roadways because of the former use of lead-containing fuels.
- Incidental spills of PCB-containing oils.
- Releases from a former creosote plant located immediately west of the site.

Analysis of river sediments identified impact from PAHs, metals and PCBs, and analysis of surface water identified impact from PAHs and metals. The samples were collected immediately upriver of the site, bordering the site, and immediately downriver of the site. The sample in front of the site was collected in the discharge area of the stormwater outfall which drains stormwater from an extensive area around the CHS. The piping system, which also passes through the impacted sites west of the CHS, is tidally influenced and drains groundwater which seeps into it. Evaluation of the data indicates that the major source of the impact to the Cooper River estuary is this stormwater outfall.

The potential for direct human exposure to the contaminants on the site is not believed to be significant. This conclusion is based on the following:

- Ambient Air - The contaminants are not volatile and do not pose a vapor phase hazard. This position is supported by the absence of ambient air impact detected by previous studies and the absence of widespread impact to surface soils.
- Groundwater - The groundwater at the site is brackish and not suitable for a potable water source regardless of the amount of contamination. There is also no significant potential for impacted groundwater to migrate to deeper usable aquifers.
- Soil - The surface soil is not significantly impacted except for limited areas, and the site is secured. Personnel performing excavation activities, however, should be properly trained to handle impacted subsurface soils which underlie significant portions of the site.
- Surface Water - There are no drinking water supply intakes downstream or in a tidally connected upstream location from the CHS.

However, the elevated concentrations of PAHs, metals, and PCBs in the river sediments near the stormwater outfall and immediately downriver of the outfall may cause exposure to environmental receptors such as fish and crustaceans. The consumption of these organisms could also result in limited human exposure to the impact.

Based on the widespread extent of relatively low contaminant concentrations, remediation of the impact is neither technically feasible or justified – especially considering the groundwater is not a potable water source. However, as part of site development, appropriate measures should be taken to mitigate and contain the impact in order to minimize discharges to the Cooper River.

The primary migration pathway for impact to reach the Cooper River is through discharges from the stormwater piping. Rerouting the stormwater piping so that it does not pass through contaminated areas of the site or surrounding sites where impacted groundwater can infiltrate the piping and then discharge to the Cooper River will prevent the majority of the contaminants from this area from entering the river. The City of Charleston has agreed to perform this project as part of site development.

Additional containment and mitigation of the impact on the site can be accomplished by many techniques. The specific techniques will be determined as part of subsequent studies.

## EXPANDED SITE INSPECTION REPORT

### NATIONAL PARK SERVICE CHARLESTON HARBOR SITE CHARLESTON, SOUTH CAROLINA

#### I. INTRODUCTION

This document presents the details of the Expanded Site Inspection (ESI) of the National Park Service (NPS), Charleston Harbor Site (CHS) located in Charleston, South Carolina. The site, shown on Figure 1, covers approximately 4 acres and borders the Cooper River, a saline, tidal river approximately 1 mile wide in the area of the site. Previous environmental site investigations on the CHS and surrounding sites have identified soil impacted by organic compounds typical of creosote and coal tar, and lead and other metals typically contained in marine paints. This ESI provides data on the source, extent, and severity of impact to the CHS, and evaluates potential migration pathways and receptors.

The site is presently an undeveloped, relatively flat, grassy field. The NPS plans to construct a visitors center and tour boat dock on the site. The tour boats will provide transportation to the Fort Sumter National Historical Monument, which is located on an island in Charleston Harbor. A portion of the site will also be leased to the City of Charleston for construction of the South Carolina Aquarium. As shown on Figure 2, a privately owned parcel less than 1 acre adjoins the southeastern corner of the CHS. Although not formally a portion of the CHS, it has been included in the ESI at the suggestion of regulatory agency personnel to provide more complete data on overall site conditions.

Because of the impact identified on the CHS, portions of these projects are being delayed pending determination by the Environmental Protection Agency (EPA) of the significance of the impact. In particular, the EPA has agreed to advise the NPS on potential mitigation measures and related development issues. The site must also be evaluated by the EPA using the Hazard Ranking System (HRS) for potential inclusion on the National Priority List (NPL). Therefore, this ESI has been conducted to provide the EPA data to perform these evaluations.

#### II. SITE BACKGROUND AND HISTORY

The site, shown on Figure 2, is located in an area of the Charleston Peninsula that has been developed since the mid-1700s. The history of the site through 1938 is presented in a document entitled "Historical Study, Fort Sumter National Monument, Dockside II"

prepared by Clark G. Reynolds in 1987, a copy of which is included in Appendix I. This study documents that the site was originally open water of the Cooper River estuary. In 1767, the southern edge of the site was filled and developed as one of the largest wharves in North America. The western edge of the site was filled in the 1800s and used as part of a lumber yard.

The majority of the site remained a tidal flat until approximately 1940 as shown by an aerial photograph of the site taken at approximately that time. A copy of this photograph is included in Appendix II. Between 1940 and 1942, the western half of the site was filled. The eastern half of the site was used for ship docking/repair as indicated by the reference to "ship ways" shown by the 1942 Sanborn Fire Insurance Map included in Appendix II. A 1967 aerial photo shows the site completely filled and used for dry docks. A 1981 aerial photo shows the site as an empty field similar to its present condition. Copies of these aerial photos are also included in Appendix II.

The Chain of Title for the site is included as Table 1. This information was provided by the most recent former owner Mr. George E. Campsen, Jr. and dates back to 1887. This data shows that the CHS has been included as a portion of sites where industrial activities occurred. However, as noted above, the majority of the site itself was not filled until after 1940.

No underground public utilities or storm drains are present at the site with the exception of subsurface piping contained in the drainage easement shown on Figure 2. The drainage easement is located in the approximate area of a former tidal creek that extended westward over 1/2 mile along the present route of Calhoun Street as shown in many of the maps in Appendix I. This tidal creek was progressively filled during the development of the area. The stormwater piping in the easement terminates as an outfall to the Cooper River. Much of the eastern portion of Calhoun Street and surrounding areas is drained by this outfall. The stormwater piping is tidally influenced and is completely submerged at high tide.

Since there are no storm water drains on the site, most precipitation falling on the site infiltrates site soil.

Adjoining properties were used for a variety of industrial purposes as shown by the historical maps included in Appendix I. The South Carolina Electric and Gas Company (SCE&G) substation site shown on Figure 2 and in some of the aerial photos in Appendix II is the former location of a manufactured gas plant (MGP) that operated from the late 1800s through the 1950s. Coal and/or oil were heated and a variety of products were

generated, including manufactured gas (vapor form), light and heavy petroleum products, coal tar, and coke.

The Calhoun Park site shown on Figure 2 was the location of a lumber yard for much of its developed history. Based on evaluation of Sanborn Fire Insurance maps, the site was used by the Fernoline Chemical Company to treat wood with creosote during some of the period between 1884 and 1902.

Adjoining the site to the south are the Dockside Condominiums. This site was formerly a heavily developed shipping wharf and ship repair facility as shown by the 1940 and 1967 aerial photographs included in Appendix II. A "Naval Store and Rosin Yard" was located on the site in the late 1800s. This yard included areas used for turpentine storage.

### III. PREVIOUS ASSESSMENT ACTIVITIES

Numerous previous assessment activities which provide data on the source, extent, and severity of impact have been performed on the subject site and some surrounding sites. These surrounding sites, shown on Figure 2, include the Ansonborough Homes, Calhoun Park, and SCE&G substation. These assessments and a brief scope of each investigation are presented in Table 2.

#### III.A - Surrounding Sites

Previous work provides a significant amount of data on the Ansonborough Homes and Calhoun Park sites located west of the subject site. This data shows that subsurface soil and groundwater underlying these sites are significantly impacted. The primary constituents identified at these sites are polynuclear aromatic hydrocarbons (PAHs) that are common constituents of creosote and coal gasification byproducts such as heavy oil and coal tar.

This finding is consistent with the presence of a several inch thick layer of solidified tar in the upper 1 to 2 feet of soil underlying large portions of the Calhoun Park and Ansonborough Homes sites (Davis & Floyd, Inc., September, 1989). Elevated concentrations of volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), and metals have also been detected in limited areas of these sites and the adjacent SCE&G site.

A dense, non-aqueous phase liquid (DNAPL) was detected in five of the six monitoring wells installed at the Calhoun Park and Ansonborough Homes sites (Davis & Floyd, Inc., December, 1990). The thickness of the DNAPL is reported to be 8 inches or

less in four of the wells. However, the well located at the northeast corner of Calhoun Park is reported to contain over 6 feet of DNAPL. The presence of 6 feet of DNAPL in this well demonstrates significant impact at this location, although the thickness of DNAPL in the subsurface is probably less than 6 feet since DNAPLs can accumulate in wells at greater thicknesses than are present in the surrounding subsurface.

The South Carolina Department of Health and Environmental Control (DHEC) performed a Site Screening Investigation (SSI) of the Ansonborough Homes, Calhoun Park, and SCE&G sites. A copy of the text of this report is included in Appendix III. This study developed data on exposure pathways through analysis of surface soil, surface water, sediments, and ambient air. The SSI also includes extensive data on surrounding populations.

### **III.B - National Park Service Charleston Harbor Site**

At the CHS, the previous environmental investigations were limited to subsurface soil extending to a maximum depth of approximately 5 feet below land surface. Each of these investigations is noted below, and the sample locations are shown on Figure 2.

- Davis and Floyd, Inc. collected two discrete soil samples from depths less than or equal to 4 feet below land surface and analyzed them for the EPA's Appendix IX constituent list. A copy of these analyses is included in Appendix IV.
- Chen Northern, Inc. collected 14 composite soil samples from depths less than or equal to 5 feet below land surface and analyzed them for the complete Hazardous Substances List of constituents. The findings of Chen Northern soil investigation are summarized in their May 1991 "Preliminary Assessment Report" included in Appendix V.
- General Engineering Laboratories (GEL) collected two samples composited from soil recovered during the construction of test pits installed as part of the Test Pile Program. The Test Pile Program was conducted in early 1992 to provide data on soil load bearing capacities for use in the Aquarium design. These samples were analyzed for Target Compound List (TCL) constituents, lead, hazardous waste characteristics, and other parameters necessary to obtain a permit for offsite disposal of soil generated by the pile construction. The findings of this investigation are included in Appendix VI.

Like the adjacent sites located west of the subject site, these assessments detected soil impact, although no free product or solidified tar was identified. The impact detected was primarily from PAHs with concentrations of total PAHs as high as approximately 50 milligrams/kilogram (mg/kg). Significant impact from metals, primarily lead, was also detected. PCBs were detected at a maximum concentration of 1 mg/kg. No VOCs were detected at concentrations exceeding 50 micrograms/liter (ug/l). Phenolic compounds were

not detected although they have been detected on adjoining sites. In addition, the analyses performed by GEL indicated that the soil is not a characteristic hazardous waste.

As part of the June 1992 "Site Screening Investigation" performed by DHEC, surface water and sediment samples were collected at the stormwater drainage outfall on the subject site. Elevated concentrations of PAHs were identified in the sediment sample; however, no impact was identified in the surface water sample. These findings are included in Appendix III.

### **IILC - Ambient Air**

The previous studies of the CHS and surrounding sites include substantial data on potential impact to ambient air from the contaminants identified in the soil and groundwater. Ambient air analyses performed as part of these studies identified no impact to ambient air in either open areas of any site or in residences of Ansonborough Homes (Davis & Floyd, Inc., September, 1989; Davis & Floyd, Inc., September, 1991; General Engineering Laboratories, October, 1991; DHEC, June, 1992). These findings indicate that ambient air in unconfined areas is not impacted by site contaminants. Impact was identified in the crawlspace underlying two of the residences of Ansonborough Homes and just above soil borings constructed during investigation of the Calhoun Park site.

## **IV. HYDROGEOLOGIC AND GEOLOGIC SETTING**

Significant data on regional and site hydrogeology has been generated in earlier reports and is summarized below. Much of the data on groundwater use in the area is taken from DHEC's "Site Screening Investigation" for the adjoining Calhoun Park/Ansonborough Homes/Coal Gas site.

### **A. Regional Setting**

The Charleston Peninsula, which includes the CHS, is underlain by the following geologic units as presented below.

<u>Name</u>	<u>Description</u>	<u>Estimated Hydraulic Conductivity (cm/sec)</u>	<u>Depth of Occurrence (feet)</u>
Terrace Deposits	Fine to medium grained sands, shelly sands, and shell beds	10 <sup>-4</sup>	0-50
Cooper Formation	Sandy, calcareous phosphatic limestone and marl with layers of clay	10 <sup>-8</sup>	50-225
Santee Limestone	Fossiliferous, locally phosphatic limestone	10 <sup>-4</sup>	225-375
Black Mingo	Fossiliferous limestone, argillaceous sands, sandstones and clays	10 <sup>-4</sup>	375-725
Pee Dee	Fossiliferous, muddy sands, and silty and sandy calcareous clays	10 <sup>-6</sup>	725-1150
Black Creek	Muddy sands, silty clays, and shelly limestone	10 <sup>-6</sup>	1150-1950
Middendorf	Feldspathic sands, clay, silty clay, and clayey silt	10 <sup>-6</sup>	1950-3000

This stratigraphy is believed to be generally representative of the subject site except for the nature of the uppermost sediments and the depth to the Cooper Formation. Based on the soil boring logs contained in Appendix VII, the stratigraphy from land surface to a depth of 80 feet can be summarized as follows.

<u>Name</u>	<u>Description</u>	<u>Estimated Hydraulic Conductivity (cm/sec)</u>	<u>Depth of Occurrence (feet)</u>
Fill	Sand, silt, and clay with varying amounts of debris including gravel, sawdust, wood pilings, and timbers	variable	varies from 0-4 to 0-24
Clayey, sandy silt	Gray to black, plastic, and cohesive silt with localized occurrences of sand strata	10 <sup>-7</sup>	base of fill (4-24) to 80
Cooper Formation	Sandy, calcareous phosphatic limestone and marl with layers of clay	10 <sup>-8</sup>	80-225+

The presence of relatively impermeable silt deposits overlying the Cooper Formation is consistent with the site's location adjacent to a tidal river. This clayey, sandy silt strata, combined with the underlying Cooper Formation, is the uppermost aquitard.

The Cooper Formation, directly underlying the silt strata, is a documented regionally extensive aquitard. The Cooper Formation prevents interconnection between the uppermost aquifer and lower aquifers for at least a 2 mile area around the CHS site. In the area of the CHS, it is approximately 200 feet thick as indicated by regional studies and the boring log from a well installed at the MGP in 1911. The log from this well is contained in an appendix of DHEC's SSI of the adjoining sites. There are no known wells or foundation piles which penetrate the Cooper Formation on the CHS. The site setting is discussed in greater detail in the following section.

## **B. Site Setting**

Data used to determine the site geology and hydrogeology was gathered from the following sources:

- The Preliminary Soil Investigation conducted to obtain data used to develop the ESI work plan
- Foundation investigations conducted by Soil Consultants, Inc.
- Well logs developed as part of this investigation

The lithologic logs prepared during the Preliminary Soil Investigation and the foundation investigations are included in Appendix VII. The well logs developed during this investigation are included in Appendix VIII. The soil sample locations are shown on Figure 3, and the monitoring well locations are shown on Figure 4.

The lithologic descriptions show that the uppermost soil strata is composed entirely of fill. Except for locations in the area of the tidal zone adjacent to the Cooper River, the fill is primarily silt and sand with varying amounts of debris. In the area of the tidal zone, the fill is composed primarily of clay. The fill overlies native fine grained sediments deposited in a former tidal marsh/shallow fluvial environment. These sediments are soft, plastic, and cohesive.

Field evaluation of these sediments identify them as clay containing varying amounts of silt and sand. However, a sieve analysis of a sample collected from 9 to 11 feet below land surface at the location of S-1, shown on Figure 4, shows that the soil is a clayey sandy silt. Permeability of the sample, which was collected in a shelby tube, was

measured to be  $1.0 \times 10^{-7}$ . This low permeability confirms that this unit is an aquitard. A copy of the sieve and permeability analyses are included in Appendix IX.

The lithologic descriptions were used to construct Figure 5, a structural contour map of the upper surface of the aquitard. This map was constructed using SURFER software which uses an equation to determine and smooth the surface which best fits the known data points. As a result, some contouring errors occur in areas of missing data and near the edges of the contoured area, such as in the northeast edge of Figure 5.

As shown by these figures, the thickness of the fill varies significantly across the site. Along the western border of the site, the thickness varies from approximately 4 to 12 feet. The 12-foot thickness occurs in the area of the drainage easement and may be related to the former presence of a creek in this area. From the western edge of the site, the fill generally thickens to the area of the present shoreline. Proceeding offshore, the fill thins and changes from primarily sand to clay.

Figure 5 identifies potential migration pathways where the sandy fill is relatively thick. DNAPL would tend to migrate into these "troughs" since it is heavier than water and will migrate to the bottom of an aquifer. One of the pronounced potential migration pathways generally parallels the drainage easement, the former location of a creek. At various times during the site history, the creek was likely dredged to a greater depth than the remainder of the site in order to accommodate ships at the wharves located along the southern edge of the site. Another "trough" where the sand thickens originates in the areas of GEL borings B-2 and D-3 and trends to the northeast.

The water table at the site is encountered at a depth 2 to 4 feet below land surface. Measurements of groundwater elevations in the groundwater monitoring wells installed as part of this study show that variations up to 0.20 foot can be caused by tidal influences. Figure 6 is a potentiometric surface map based on groundwater elevations measured in the 12 wells at the site. The overall flow indicated by these measurements is toward the Cooper River. While net groundwater flow toward the Cooper River is expected, the overall groundwater flow regime for the site is probably highly variable considering the inhomogeneity of site soils and variations caused by tidal influences.

### C. Area Groundwater Use

Within a 4-mile radius of the site, shallow groundwater is not used for drinking water, and there are no known private wells. Groundwater in aquifers below the Cooper Formation is used for industrial, irrigation, domestic, and community water supply. The only public supply wells within a 4-mile radius are located in Mount Pleasant, which is on

the opposite side of the Cooper River. Groundwater analysis by DHEC has not identified impact to these wells. These wells are part of the City of Mount Pleasant supply system which serves 31,746 people, as reported in DHEC's Site Screening Investigation.

Except for the Mount Pleasant, the public water supply in the Charleston area is provided by the Commissioners of Public Works of the City of Charleston. Their water is obtained from surface water sources upgradient of the site. The intake for over 90% of the water is the Edisto River, which is located over 30 miles from the site in a different drainage basin.

## V. SAMPLING AND ANALYSIS

As part of the ESI, samples of potentially impacted media were collected and analyzed. These media included:

- Surface soil
- Subsurface soil
- Groundwater
- Surface water from the adjacent Cooper River estuary
- Sediment from the adjacent Cooper River estuary

The Certificates of Analysis for all of these analyses are included in Appendix X and summarized in Tables 3-13. A complete laboratory data package including Quality Assurance/Quality Control information has been submitted to the EPA and DHEC as a separate document.

Typically, ambient air samples would also be collected for laboratory analysis. However, the non-volatile nature of the contaminants indicates that there is not a significant potential for a vapor phase hazard to the site ambient air. Furthermore, the potential for ambient air impact from airborne dust is also unlikely since the site is vegetated. These conclusions are supported by the ambient air analyses performed by DHEC and Davis and Floyd on adjoining sites, and the analyses previously performed by GEL on the subject site. These analyses did not identify impact to ambient air on any of the sites. This conclusion is further supported by the relatively low contaminant concentrations identified in surface soils on the CHS as discussed below.

### V.A - Surface and Subsurface Soil

During installation of the monitoring wells, soil samples were collected for laboratory analysis from nine locations at the site using the techniques described in Appendix VIII.

The locations are shown on Figure 4. Each soil sample location corresponds to the groundwater monitoring well with the same numeric designation. At each location, samples were collected at the following depth intervals.

LOCATION AND DEPTH INTERVALS OF SOIL SAMPLES

<u>Sample</u>	<u>Land Surface</u>	<u>Water Table</u>	<u>Aquitard Interface</u>	<u>2'-5' Into Aquitard</u>
S-1	0"-6"	3'-4'	7'-9'	13'-15'
S-3	0"-6"	3'-4'	9'-13'	17'-19'
S-4	0"-6"	3'-4'	11'-13'	15'-17'
S-6	0"-6"	3'-4'	12.5'-14'	18'-20'
S-8	0"-6"	3'-4'	19'-23'	26'-30'
S-9	0"-6"	3'-4'	13'-17'	23'-25'
S-10	--	3'-4'	10'-12'	--
S-11	--	3'-4'	27'-31'	--
S-12	--	3'-4'	13'-15'	19'-21'

These locations and depth intervals were selected to provide data on the vertical and horizontal extent of impact.

All of the samples were analyzed for the following:

- TCL Base/Neutral Extractable Compounds (BNs), including tentatively identified compounds (TICs) - PAHs are a subset of BNs
- Polychlorinated Biphenyls (PCBs)
- Arsenic, Barium, Cadmium, Chromium, Lead, Mercury, Selenium, Silver

For the aquitard interface samples collected from locations S-1, S-3, and S-4, this list was expanded to include the complete TCL and Target Analyte List (TAL). The complete TCL and TAL includes volatile organic compounds, acid extractable compounds, herbicides, pesticides, cyanide and a comprehensive list of metals. This expanded parameter list was chosen for these locations to identify the nature of the contaminants migrating onto the site.

The results of these analyses are summarized in Tables 3-10, and the Certificates of Analysis with the Chain of Custody documents are included in Appendix X. Figures 7, 8, and 10 show the distribution in site soils of TCL PAHs, PCBs, and lead and mercury, respectively.

#### **V.A.i - Surface Soil - 0"-6"**

Analysis of the six surface soil analyses, summarized in Table 3, did not detect PAHs identified by the earlier studies on the subject site and surrounding sites. One TIC, 2-pentanone-4-hydroxy-4-methyl, was identified in five of the surface soil samples. This compound was also detected in the laboratory blank and is believed to be a laboratory contaminant introduced in the sample extraction process. Therefore, it is not included on the summary table.

PCBs were identified at four locations; the concentrations detected were all approximately 1 ppm or less except for location S-1 where 88.8 ppm was detected. No other organic compounds were identified.

Table 3 also summarizes the metals detected in surface soils. This table includes the concentrations detected in two background surface soil samples analyzed by DHEC as part of the SSI performed at the adjoining site. This table shows that the metals concentrations detected are comparable to background concentrations except for arsenic and mercury. Furthermore, the concentrations of arsenic detected are all below 9 ppm and are not significantly elevated above typical naturally occurring concentrations in soils. However, the concentrations of mercury detected are greater than typical natural concentrations and may be related to the former industrial activities on the site and surrounding sites.

These results show that surface soil on the site is not as impacted as on surrounding sites - probably as a result of the more recent filling of this site compared to nearby sites. These findings provide additional evidence that there is no apparent potential vapor phase hazard under ambient conditions.

#### **V.A.ii - Soil at the Water Table (3'-4')**

The analyses of nine soil samples collected at the water table, summarized in Table 4, detected impact from PAHs at five of the locations, S-1, S-9, S-10, S-11, and S-12. The presence of these compounds at the water table, considered with their absence at land surface (0"-6"), demonstrates that the impact is migrating to the site in the groundwater and suggests that it was not present in the soil used to fill the site surface. When the site was a marsh/open water prior to filling, impact could also have migrated into these deeper sediments from surface water runoff from the surrounding sites.

PCBs were detected at a concentration of 225 ppm in the sample collected from S-1. Considered with the 88.8 ppm PCBs detected in surface soil at this location, a release of PCBs apparently occurred near S-1.

The results of the metals analyses are summarized in Table 6. Elevated concentrations of arsenic, barium, and lead were detected at the location of S-10. Most significant among these was the elevated concentration of lead. An elevated lead concentration was also detected at S-9. Potentially elevated concentrations of mercury were also detected.

#### **V.A.iii - Soil at the Interface with the Uppermost Aquitard**

PAHs were detected in six of the nine samples collected at the interface between the surface soil and the uppermost aquitard. As summarized in Table 5 and illustrated by Figure 7, the highest concentrations were detected at S-1, S-9, and S-12. Intermediate concentrations were detected at S-3, S-6, and S-11. No PAHs were detected at S-4, S-8, and S-10.

This contaminant distribution suggests that there are two primary migration pathways onto the site for organic compounds typical of coal tar. These are: 1) in groundwater entering the site along the northwestern border, and 2) in groundwater which infiltrates the stormwater piping system that passes through the site along the drainage easement. The area south of the drainage easement does not appear to be significantly impacted by PAHs.

As summarized in Table 7, analysis for TCL VOCs in samples S-1, S-3, and S-4 detected impact in all three samples. The impact in S-1 shows that VOCs are present in site soils in the northwest corner of the site. However, the VOCs are at a relatively low concentration compared to the PAHs indicating that impact from PAHs is more severe than from VOCs. The primary VOC compounds detected are mononuclear aromatic hydrocarbons such as benzene, toluene, ethylbenzene, and xylene (BTEX), and dinuclear aromatic hydrocarbons such as indene and benzofuran. These compounds are coal distillates and are commonly found at MGPs.

Except for 97.5 ppb xylene detected in S-3, the compounds detected in S-3 and S-4 are methylene chloride and acetone. Methylene chloride was also detected in laboratory method blanks and acetone was detected in the field and trip blanks collected with the groundwater samples. These occurrences indicate that these compounds are the result of laboratory interferences and are not representative of site conditions. The presence of xylene in S-3 may be related to the former MGP although xylene is common in many fuels and solvents.

The results of the metals analyses are summarized in Table 8. Concentrations of some metals, such as arsenic, appear to be elevated over typical naturally occurring

concentrations. However, the concentrations detected do not appear to be significantly elevated compared to those commonly found at industrial sites.

#### **V.A.iv - Soil 2'-5' Into the Uppermost Aquitard**

As summarized by Table 9 and illustrated by Figure 7, PAHs penetrate the uppermost aquitard. Compared to the concentrations detected at the interface with the aquitard, the concentrations detected below the interface were:

- Significantly lower at S-1 and S-6
- Comparable at S-3 and S-9
- Higher at S-12

Consistent with analyses at other depths, no impact was detected at the locations of S-4 and S-8.

The greater penetration at S-12 may result from the presence of a DNAPL at this location since the higher density of free product may promote penetration of the aquitard. These findings demonstrate that the aquitard retards, but does not prevent, the downward migration of contaminants. However, considering that the uppermost aquitard extends approximately 70 feet to the Cooper Formation, which is over 200 feet thick, it can be concluded that on the CHS contaminants will not penetrate these aquitards and migrate into lower aquifers.

The results of the metals analyses are summarized in Table 10. Evaluation of these results does not identify any significantly elevated metals concentrations compared to typical naturally occurring ranges of concentrations.

#### **V.B - Groundwater**

To obtain data on the extent and severity of groundwater impact on the site, 12 shallow groundwater monitoring wells were installed at the locations shown on Figure 4. The well construction details, including lithologic logs, monitoring well schematics, and latitude and longitude coordinates, are included in Appendix VIII.

In each well, the bottom of the screen was set approximately 1 foot into the aquitard and screened upwards into the fill where impact would be most concentrated. A 2-foot sump was installed below the screen in each well to collect sediment and any DNAPL free product which infiltrated the well.

An effort was made to screen each well above the water table to detect light non-aqueous phase liquids (LNAPL). However, the water table in most locations is less than 3 feet below land surface making it difficult to set the screen above the water table and still

maintain well integrity. Therefore, the top of the screen is slightly below the water table in some wells. However, as shown by the analyses discussed below, there are no indications that LNAPLs are present at the site.

The wells were developed and sampled as described in Appendix XI. Free product was not detected in any well except for MW-12. Approximately 2.5 inches of a black viscous DNAPL were identified in the sump of this well; therefore, it was not developed and samples of product were collected on September 4, 1992, and September 15, 1992. These samples were combined for laboratory analysis. When all of the wells were rechecked for the presence of DNAPLs on September 28, 1992, no measurable thickness of product was detected in MW-12 although product residue was noted on the tip of the probe. No product was detected in any of the other wells. These findings show that free product is present in only small quantities along a limited area of the northern boundary of the site.

Groundwater (or product in the case of MW-12) from each well was analyzed for the following:

- TCL BN (including TICs) - PAHs are a subset of BNs
- PCBs
- Total Dissolved Solids (TDS)
- Arsenic, Barium, Cadmium, Chromium, Lead, Mercury, Selenium, Silver

The analysis of groundwater samples collected from wells MW-1, MW-2, MW-3, and MW-4 was expanded to include the complete TCL and TAL. This expanded parameter list was chosen for these locations to identify the nature of the contaminants migrating onto the site. The results of these analyses are summarized on Tables 7, 11, and 12, and the Certificates of Analysis are included in Appendix X with Chain of Custody documents. Figures 7-10 illustrate the distribution of various parameters in groundwater.

The concentration of TDS in water provides a measure of the overall quality and suitability of water for use as potable water. Some concentrations and standards for TDS, and the average and range of TDS concentrations detected at the CHS are:

<u>Concentration, ppm</u>	<u>Media/Regulatory Limit</u>
10,000+	Saline Water
1,000-10,000	Brackish Water
500	Safe Drinking Water Act (SDWA) Secondary Maximum Contaminant Level
3,288	Average TDS in CHS Groundwater
1,100-8,030	TDS Range in CHS Groundwater

As demonstrated by this information, the TDS at the CHS is typical of brackish water and is far in excess of the SDWA limit for TDS. This finding is consistent with the site being located on fill overlying a former salt marsh and bordering a saltwater river. Examination of the TDS concentrations in each well, shown on Table 9, shows that the impact is not related to a contaminant source but rather is representative of natural conditions; in fact, the highest TDS concentration was detected in MW-4 where analyses have not identified significant impact.

Considering this information, the groundwater in the uppermost aquifer at the CHS is not a potential potable water source because of its brackish nature. The EPA standard for designating groundwater non-potable based on TDS is 10,000 ppm. However, this is not a realistic standard considering the SDWA limit and historical area groundwater use. Historically, wells on the Charleston Peninsula, especially in proximity to tidal rivers, have been drilled to aquifers below the Cooper Formation because of the poor water quality in the uppermost aquifer. Therefore, SDWA standards and South Carolina Class GB standards should not be applicable to groundwater in the uppermost aquifer underlying the site.

Figure 7 shows the total concentration of PAHs in the groundwater samples as well as in the soil samples. Figure 9 is an isoconcentration map of total PAHs. Consistent with the soil samples, this figure illustrates that:

- Contaminant concentrations are greatest in the northwestern portion of the site closest to the former MGP.
- The area of the drainage easement is a preferential migration pathway as demonstrated by the impact detected in wells MW-3 and MW-9.
- Impact from PAHs has not occurred in the southern portion of the site or directly across the street from the former Fernoline Chemical Company where creosoting operations are thought to have occurred.

This distribution of contaminants indicates that the primary source of impact from PAHs to the CHS is the former MGP. This conclusion is based on the presence of the greatest impact located proximal to the MGP and the absence of impact located adjacent to the former Fernoline Chemical Company.

Evaluation of metals detected in groundwater, summarized in Table 12, shows that only lead and mercury concentrations appear to be elevated. Figure 10 illustrates the distribution of these elements in groundwater; it shows that lead concentrations are elevated in wells MW-3, MW-9 and MW-10, and mercury concentrations are elevated in well MW-10. The concentrations detected in these wells are higher than those detected in wells closer to the former MGP indicating that the former MGP is not the source of these elevated metals.

The presence of elevated lead in wells MW-3 and MW-9, located along the drainage easement, indicates that the impact may be related to surface water runoff. Considering the history of the area, a potential source of lead is marine paints used at the former ship building and repair industry that operated on the CHS and adjacent properties to the south of the CHS. Another source of lead likely to have contributed to the elevated concentrations in MW-3 and MW-9 is non-point source runoff from roadways. Elevated lead concentrations are common along roadways because of the former use of lead additives in gasoline.

PCBs were detected in groundwater samples collected from MW-7 and MW-10 at concentrations of 1.23 and 4.91 ppb, respectively. The source of these PCBs is not evident, the concentrations are relatively low, and the occurrences appear to be isolated.

Significant concentrations of VOCs were not detected in the analyses of MW-1 through MW-4, although mononuclear aromatic hydrocarbons were detected in MW-1 and MW-3. However, as shown by Table 7, the maximum concentration of any of these compounds was 71.3 ppb of xylene detected in MW-1. Toluene was detected in MW-2 and MW-4 at concentrations which are not indicative of significant impact. Odors similar to turpentine were noted in soils and groundwater from MW-4. However, the compounds causing these odors were not identified.

### **V.C - Surface Water and Sediment**

Surface water samples SW-1 through SW-3 and sediment samples SD-1 through SD-4 were collected from the Cooper River to provide an indication of the significance of impact to the river in the vicinity of the CHS. The sample locations are shown on Figure 4

- No impact from PAHs was identified at SD-3. This sample was collected less than 125 feet from the northern edge of the site and nearer to the former MGP than any of the other samples. If significant impact were migrating to the river via groundwater discharges or overland surface water runoff, it would be reasonable to expect that this sample would have been impacted.

Evaluation of metals and PCB data identifies the following:

- The highest concentrations were detected in SD-2, collected in the discharge area of the outfall from the drainage easement. In fact, sediments in the area of the drainage outfall are the only area where PCBs were detected.
- The lead concentrations in SD-2 are over twice as high as any detected in soils at the CHS during this study. With few exceptions, the concentrations of arsenic, chromium, mercury, and PCBs are also higher than those detected in soils collected from the CHS.
- Lead was detected in SW-2 and SW-3. Like the sediment samples collected at these locations, lower lead concentrations were detected at SW-3.

These observations show that metals and PCBs, especially lead, are discharging to the river through the drainage easement. The elevated concentrations of metals and PCBs in SD-2 compared to soils on the CHS indicate that the source of metals is not the CHS; rather, these contaminants probably originate from runoff in other portions of the drainage basin which discharge through the outfall on the CHS.

The presence of lead in the SD-3/SW-3 sample, where no PAHs were detected, further indicates that the metals impact is not caused by the MGP. The metals detected at this location are likely related to surface water runoff from the adjacent Luden's Marine site where ship repair is performed.

## VI. EXPOSURE PATHWAYS

The evaluation performed as part of this and earlier investigations of the site and surrounding sites provides significant data to evaluate potential exposure pathways to the contaminants present on the CHS. Potential human exposure pathways to environmental contaminants are through:

- Ingestion of impacted soils, water, or impacted foods
- Inhalation of impacted air
- Dermal exposure to contaminants contained in soils or water

Significant potential environmental exposures from site contaminants would be through discharges to the adjacent Cooper River estuary.

except for location SD-4 which is shown on Figure 1. Relative to net flow in the river, the locations are:

SD-1/SW-1	Immediately downstream and adjacent to the southern edge of the CHS
SD-2/SW-2	Adjacent to the CHS in the discharge area of the outfall from the drainage easement at the CHS
SD-3/SW-3	Approximately 125 feet upstream from the northern edge of the CHS
SD-4	3/4 mile downstream from the site

The sample collection procedures are described in Appendix XII.

All of the samples were analyzed for:

- TCL BN (including TICs) - PAHs are a subset of BNs
- PCBs
- Arsenic, Barium, Cadmium, Chromium, Lead, Mercury, Selenium, Silver

The results of these analyses are summarized in Table 13, and the Certificates of Analysis are included in Appendix X.

Table 13 shows that the highest concentration of PAHs in sediments were detected in the downstream sample, SD-1. Lower concentrations were detected at the drainage outfall, SD-2, and no PAHs were detected in the upstream sediment sample, SD-3, or in SD-4, located 3/4 mile downstream of the site.

Organic compounds typical of the impact on the CHS and surrounding sites were not detected in any surface water sample except SW-2. The presence of low concentrations of naphthalene and 2-methylnaphthalene in this sample indicates that impacted groundwater from either the CHS site and/or sites inland of the CHS is discharging to the river along the drainage easement.

These findings show that discharges from the area of the CHS are impacting river sediments in front of and at least a short distance downstream of the site. The distribution of compounds indicates that the primary migration pathway to the river is via discharges from the drainage easement. This conclusion is based on the following:

- The highest contaminant concentrations were detected in SD-1 which was collected near the southern end of the site where no impact from PAHs has been identified in the subsurface soils or groundwater. This shows that the impact in SD-1 was not the result of impacted groundwater seeping into the river; instead, it must have resulted from inland sources discharging to the river through the stormwater drain.
- Surface water discharging through the drainage easement contained low concentrations of PAHs.

As discussed in section V.A.i, surface soils (0"-6") on the CHS are not significantly impacted by organic contaminants with the exception of localized occurrences of PCBs. Except for mercury, concentrations of metals detected in surface soils at the CHS are comparable to background concentrations or typical naturally occurring concentrations.

An acceptable concentration of mercury in soils can be calculated from the Referenced Verified Dose (RfD) of mercury. Based on the RfD of 0.0003 mg/kg/day for mercury, a 16 kilogram child could ingest 0.2 grams per day for five years of soil impacted with up to 24 mg/kg of mercury without exceeding the RfD. The assumption that a child would consume 0.2 grams per day is conservative and is based on the amount of soil an unusually active (pica) child would consume. The highest concentration of mercury detected in the soil samples collected at the CHS is 1.37 mg/kg – far less than 24 mg/kg. Therefore, the elevated concentrations of mercury on the site do not pose a health risk.

Since access to the site is restricted, there is no present threat from soil exposure to the public from the localized PCBs in surface soils. However, based on the presence of significant soil impact in the subsurface, individuals involved with excavation activities at the site should be properly trained to avoid prolonged exposure to the subsurface soils.

Ambient air impact is not a potential exposure pathway from the contaminants on the CHS because:

- Widespread surface soil impact is not present
- The primary contaminants identified are non-volatile
- The site is covered with vegetation, thereby minimizing airborne dust

Previous evaluations of open excavations on the CHS have not identified a vapor phase hazard. However, periodic ambient air monitoring should be performed during excavation activities in areas of the site where significant subsurface impact has been identified.

Exposure to site contaminants through ingestion of groundwater is not a potential exposure pathway since the groundwater in the uppermost aquifer is not potable. The brackish groundwater is believed to be caused by the salinity of the adjacent Cooper River and by the native soils which were part of a saltwater estuary until filled. Therefore, there is no significant potential for the groundwater in the uppermost aquifer to ever be used as a potable water source. The occurrence of an over 250 feet thick aquitard between the uppermost aquifer and deeper usable aquifers will also prevent migration of contaminants to these deeper aquifers.

There is also not a potential for contaminants to migrate to the surface water intakes of drinking water supply systems. There are no intakes downstream or in a tidally connected upstream location from the CHS.

Earlier studies have identified elevated concentrations of contaminants in oysters and blue crabs collected in the Charleston Harbor as summarized in the SSI performed by DHEC and included in Appendix III. Ingestion of oysters and blue crabs which bioaccumulate contaminants is a potential exposure pathway. However, the earlier studies do not provide adequate data to identify the source of the contaminants.

Moreover, the PAHs found on the CHS and surrounding sites are common to many products such as creosote timbers used in marine docks and fuel oils. The common occurrence of these compounds suggests that the contaminants detected in the organisms likely originate from many sources. However, regardless of whether these occurrences are caused even in part by the impact on the CHS, efforts to minimize continuing discharges to the river would be appropriate.

## VII. MITIGATION AND CONTAINMENT

Based on the extent and nature of the contaminants detected at the CHS site, remediation of the entire site is neither feasible nor warranted. Elimination of widespread, relatively low concentrations of PAHs from an inhomogenous and largely fine-grained matrix is not technically feasible. However, consistent with EPA policy, it is appropriate to take measures to contain and mitigate the impact. Performing mitigation and containment activities can 1) minimize potential future exposures and 2) minimize migration of additional contaminants on to and off the site.

This investigation has confirmed that the area of the drainage easement is a preferential migration pathway for contaminants – most of which apparently originate from off-site sources. Closing this drainage way would minimize discharges of contaminants to the Cooper River. The City of Charleston is presently in the process of rerouting this drainage as part of a project intended to eliminate flooding of Calhoun Street and other nearby areas. This project includes removing the stormwater piping from the CHS. Completion of this project will substantially reduce the discharge of contaminants to the Cooper River.

Other potential mitigation and containment mechanisms will be determined as part of subsequent studies. Regardless of the mechanism chosen, a primary consideration will be evaluating and controlling the source of the impact, which is located on an adjoining site.

## VIII. CONCLUSIONS

This ESI provides a significant volume of detailed information about the history and environmental condition of the CHS. The data shows that the soils and groundwater of

portions of the site are impacted – but to a lesser extent than that found on some surrounding sites. This variation in severity is likely related to: 1) the relatively recent filling of the CHS compared to adjoining sites, 2) the relatively limited industrial use of the site, and 3) the short duration of site use.

The field and analytical data support the conclusion that the contaminants on the site do not present a significant threat to human health. Exposure to isolated areas of significantly impacted surface soil and to contaminants while performing subsurface excavations are the only potential exposure pathways on the site. Furthermore, the exposures in these cases represent a chronic risk rather than an acute risk.

Use of groundwater as a present or future potable water source is also not a consideration at the CHS because of the naturally brackish nature of the uppermost aquifer. The contaminants present in the uppermost aquifer also will not migrate to usable aquifers due to the presence of over 250 feet of impermeable strata between the uppermost aquifer and potable water aquifers. This conclusion assumes that significant volumes of additional contaminants do not migrate to the CHS from surrounding sites.

The City of Charleston's removal of the stormwater drain system, which is the primary contaminant migration pathway to the Cooper River, will substantially reduce migration of contaminants to the Cooper River. Additional containment and remediation measures, which will be identified and implemented in future activities, will further protect the environment from discharges. To maximize the success of these measures, the source of impact must be controlled or eliminated. Since the source of the impact is on an adjoining site, these additional activities should be coordinated with the parties responsible for the adjoining sites.

As acknowledged by the EPA, complete removal of DNAPLs such as PAH compounds from fine grained soils is not technically feasible using presently available technologies. However, in the event that remediation of the site becomes necessary in the future, emerging technologies which show promise, such as in-situ bioremediation, could be employed. These technologies remediate impacted materials in place, do not require significant excavation, and do not interfere with normal site activities.